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STUDIES ON THE IGUANA TICK, *AMBLYOMMA DISSIMILE*, IN PANAMA*

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Some months ago while engaged in making a collection of the various species of snakes commonly found on the Isthmus of Panama, my attention was attracted by the number of specimens that were acting as hosts for the "iguana tick," *Amblyomma dissimile*. Over 60 per cent. of the total number of specimens collected were found to have ticks of this species attached to them. The 40 per cent. found to be free from ticks included a few that were aquatic in habits and a number of terrestrial varieties that were of a burrowing nature. Naturally, with such habits tick infestation is highly improbable. If only those specimens with habits *compatible* with infestation, such as the non-burrowing terrestrial and arboreal varieties, are taken, the numbers found with their parasitic associates tightly attached to them greatly exceed 60 per cent.

Besides being attached to snakes, this tick is also commonly found on toads and iguanas. Out of a number of these two latter animals received at this laboratory during the past two years, about 72 per cent. of the toads and 84 per cent. of the iguanas were found to be infested. Possibly this species may also attach itself to tortoises, small lizards, and other cold blooded animals, but so far the snakes, iguanas and toads have been found to be the common or representative hosts on the Isthmus.

On the snakes that have been collected I have found specimens of this tick in different stages of development, from the larval form to the sexually mature males and replete females. The larvae were found to be the more numerous. With some of the larger snakes a close search was necessary to find the small unengorged larvae, as they usually attach themselves beneath the scales of the host and are partly or entirely concealed, but a scrutiny beneath the scales usually resulted in exposing larvae. A slight raising of the scales of reptiles is strongly indicative of either the presence of larval ticks or small

* Read before the Medical Association of the Isthmian Canal Zone.

swellings caused by their having been attached previously. The nymphs when unengorged were also frequently found partly concealed beneath large scales, but when engorged were easily noticeable. Unengorged males and females were usually quite prominent. Altho the engorged females were not as numerous as the other forms, quite a number of them were found and in some instances were hanging from the side of the snake like globular pendants.

As the female of *A. dissimile* when fully replete is considerably larger than the other species of ticks found on the Isthmus — with possibly two exceptions — one may suspect that many of them before becoming fully engorged, are detached by the host passing swiftly thru thick grass, bushes and trees, over rough ground, sharp stones, etc. The engorged pendant females are prominent enough to catch on the many sharp edges of these objects and it is quite possible that many of them are torn loose in this manner during the travels of the host. It was noted that the ticks on the dorsal engorge to a larger size than those on the lateral or ventral surfaces. This is probably due to the fact that they escape the friction that those on the lower surfaces are subjected to, and also that those on the dorsum may use their claws and pulvilli to assist in holding them in position, while those on the sides and venter cling almost solely by their mouth parts.

Although *A. dissimile* has no apparent economic importance, a few studies were made on the bionomics and life history of this species in Panama which may be worthy of recording for the purpose of comparison with observations made on this tick in other localities. At the beginning of my observations, considerable difficulty was experienced in keeping suitable cold blooded hosts alive. Experiments were first tried with large toads, but they usually died within a few days when confined in cages small enough to control the dropping of the ticks. When placed in large cages and supplied with proper food they lived for considerable periods of time, but in the larger cages the smaller forms of the ticks could not be effectually controlled. As this did not give a definite record of the different stages, the use of toads for hosts was abandoned after a few trials. Iguanas were next tried and rejected for the same reason. Snakes gave the most satisfactory results as hosts.

Glass jars of three gallons capacity were used for containers. The first method adopted consisted in placing a snake in a jar and then dropping in the ticks to be observed. The top of the jar was then covered with a piece of light muslin, held in place with wide rubber bands. This prevented the escape of any of the ticks, yet allowed a sufficient air supply to prevent asphyxiating the host. Two faults were apparent with this method. First, that it necessitated the removal of the host from the container twice each day in order to search for

ticks that had dropped, many of them being hidden between the coils of the snake and could not be found without removing the latter from the jar. Second, the snake lying on the bottom of the jar created a certain amount of moisture which had a tendency to affect the ticks.

In order to correct these faults it was necessary to devise an arrangement to keep the snake from resting on the bottom of the jar. This consisted in cutting out a circular piece of wire screening about one-half inch larger in diameter than the inside of the jar. This extra one-half inch was then turned down at a right angle all around the edge. A disk of white blotting paper was cut out and placed in the bottom of the jar, the screen with the turned edge downward then being placed on this paper disk. The turned edge of the screen kept it one-half inch above the paper. The snake was then placed in the jar on the screen, the mesh of which being one-half inch, allowed the ticks to drop thru on the paper as soon as they detached from the host. Usually they crawled beneath the paper on the bottom and could easily be noticed there by elevating the jar. The screen fitting the bottom of the jar tightly could not be displaced by the movements of the snake, which latter were always too large to crawl through the meshes. This arrangement proved to be very satisfactory.

The serpents used for hosts were adolescent specimens of the large boa, *Boa imperator,* mature specimens of the rainbow boa, *Epicrates cenchria,* and the tree snake *Oxybelis fulgidus.* The specimens selected were as large as the size of the jars would comfortably accommodate.

A series of four rearing experiments were conducted, of which I record but one. This one experiment not only represents a complete life cycle of *A. dissimile* for this region but also illustrates an instance of part of the larvae dropping to molt while the remainder molted on the host. This occurred in but one out of four experiments.

On September 17, 1916, a live specimen of *Epicrates cenchria* was captured near Balboa and presented to the laboratory. When received a female *A. dissimile* was found attached on the dorsal surface about 8 inches from the snake's head. Although but about three-fourths engorged, this tick was quite large. Engorgement was completed four days later and the tick dropped from the host on September 21. This replete female which was the largest specimen of *A. dissimile* that I have observed, measured 25 mm. in length, 15.5 mm. in width, 9 mm. in height and weighed 2.4 grams. After a preoviposition period of six days this female began depositing her eggs on September 27. Daily oviposition continued until October 31; covering a period of thirty-five days. The total number of eggs deposited was 9,254, which is the maximum observed from this species.

The eggs of this species are very light brown in color when first deposited and thinly coated with a transparent viscid substance which

dries very quickly. A slight greenish tinge becomes apparent in a few days which gradually disappears as the eggs assume a darker shade of brown. Twenty-two days after they were deposited a white spot appeared on the side of each egg, caused by the development of the young embryo within the egg. These white spots becoming more pronounced as the embryos continued to develop, the eggs soon became considerably lighter on one side than on the other. An average egg measured 0.7 mm. in length, 0.5 mm. in diameter and weighed 0.143 milligrams.

The first eggs of this lot began hatching on November 6, and the last ones on December 8. This gave an average incubation period for each day's oviposition of practically 40 days. They all required about the same period of incubation.

When the young larvae emerged, the white spots noticed through the walls of the eggs were very pronounced and became more so when the larvae engorged. A newly emerged larva of average size measured 0.9 mm. in length, 0.5 mm. in width, weighed 0.2 mgm. and varied from gray to brown in color.

Within forty-eight hours after emerging the larvae separated from the mass of empty egg shells and swarmed in a cluster on the under side of the cover of the petri dish in which they were confined.

On December 30 about 200 of these young larvae were sprinkled over a constricting snake, *Boa imperator*. Within a few minutes they were actively crawling over the snake, and it appeared that when any of the scales were raised by its turning the larvae were ready to make their way beneath them. Many of them attached within fifteen minutes. When ready to attach the larva spread its legs, and after securing a grip on the skin with its claws, proceeded to force the hypostome into the skin, the palps meanwhile separating and spreading outward. It seemed to require but a few minutes and slight effort to insert the hypostome to full length. When this was accomplished the palps were extended at nearly right angles from it.

On the second day all unattached larvae were removed from the jar. The greater number of those attached were located on the dorsal surface, many of them being on the median line; some were also scattered over the lateral surfaces and a few were found on the ventral surface close to the vent.

As these larvae all began to engorge, the many scales beneath which they were attached became slightly elevated and caused the snake to have a peculiar rough appearance in place of the smoothness usually present.

Ninety-four engorged larvae dropped between January 10 and January 17 after an attachment period of from 11 to 18 days, the

greater number detaching on the thirteenth day. The remaining larvae, altho all appeared to be completely engorged, maintained their attachment at the host and did not drop.

A replete larva of average size measured 2.2 mm. in length, 1.7 mm. in width, 0.7 mm. in height, and weighed 1.5 mgm. The color varied from pale drab to light brown and chestnut brown.

At from 6 to 10 days after dropping, during which time they moved about but very little and that rather slowly, the first stages of molting was manifested and they became practically motionless. At this time while the change from larva to nymph was slowly taking place, the outer skin became dry and shriveled with a white transparent appearance at the anterior end, which appearance increased as the changes within continued.

The nymphs all emerged between January 24 and January 28, the molting period being from 11 to 15 days, with the greater number emerging on the fourteenth day. However, in our other rearing experiments we have found larvae that engorged on toads to require as long as 19 days to molt. A few hours after emerging the young nymphs became quite active and traveled rapidly about in the rearing jars in which they were confined. At this stage their legs appeared to be out of proportion in length to their small bodies.

An unengorged nymph measured 2 mm. in length, 1.5 mm. in width, 0.7 mm. in height and weighed 0.8 mgm.

On February 15 these nymphs were placed on a "tree snake," *Oxybelis fulgidus,* which was 4 feet in length and about three quarters of an inch at its largest diameter. Many of the larvae attached quite readily, those that did not attach within 24 hours being removed from the jar. The first one to leave the host dropped on February 27, requiring but 11 days to engorge. The last one dropped on March 9 after a 22 day engorgement period. Among those that dropped last were a few that appeared to have been completely engorged for several days before dropping.

An average engorged nymph measured 5 mm. in length, 3.5 mm. in width, 2 mm. in height, weighed 29.5 mgm. As with the larvae, the color was not constant and varied with individuals, from a light drab to a deep brown. After a molting period of from 8 to 16 days, with the greater number emerging on the fourteenth day, the adults began to emerge. The first one emerged on March 14 and the last one on March 23. As the individuals that remained attached to the host the longest were those having the shortest molting period — the nymph with the 22 day attachment period molted in 8 days — it is possible that they remained attached for several days after apparent repletion and the molting process had begun before dropping occurred.

A newly emerged adult female measured 5.5 mm. in length, 4 mm. in width and weighed 7 mgm. The coloration was reddish brown with lighter colored ornamentations on the scutum.

It will now be necessary to return to the engorged larvae that were left on the *Boa imperator*. As previously stated, ninety-four of the larvae dropped engorged between January 10 and January 17 while the remainder did not detach altho apparently engorged. These larvae remained on the host and molted, and the nymphs also became engorged before dropping. The replete nymphs began dropping on February 8. The last one detached on February 28. After all the nymphs of this lot had dropped, the snake was examined closely and a few of the small cast larval skins were found still attached beneath the scales. During our many rearing experiments with this tick, this is the only instance in which molting occurred on the host, and we are unable to explain what caused the irregularity in this case. However, we are glad to have been able to witness this departure from the usual procedure, as a considerable difference of opinion seems to exist regarding the life history of *A. dissimile*. Newstead (1909), in writing of this species, states: "Both the nymphs and the females mature very slowly, and it is evident that all three stages (larva, nymph and adult) are passed upon one host; so that in this respect it differs markedly from its congeneric representative, *Amblyomma cajennense*, which requires three hosts and effects its two molts upon the ground. The life cycle of *A. dissimile*, therefore, resembles that of the common cattle tick (*Margaropus annulatus australis*). Hooker, Bishopp and Wood (1912), who found that this species dropped to molt and required three hosts, in mentioning the observations by Newstead say, "The only information upon the biology of this tick that the authors have found is furnished by Newstead (1909). This author is in error in supposing that the molts are passed upon the host, as such is not the case."

After observing the instance of part of the larvae dropping to molt while the remainder molted on the host, as previously stated, we can more easily understand the difference of opinion regarding the biology of this tick.

Thirty-four adults, 17 males and 17 females, were placed on a "rainbow boa" *Epicrates cenchria*, about 4½ feet in length, on April 9. Although these adults had remained quite dormant after emerging, they became very active when placed on a host and several were attached within twenty minutes. The following morning, April 10, four were found to be still unattached and were removed from the jar. The thirty that were attached, 16 females and 14 males, were all located on the dorsal surface of the host. Eleven of these were grouped

in a small area, less than ¾ of an inch in diameter, about 4 inches from the head of the snake. Three inches from this group another cluster of eight were attached so closely together that they were lying partly on top of each other. The rest were scattered about over the dorsal and lateral surfaces. On April 11 it was noticed that some changing about had occurred and the number of individuals in the first cluster had increased to nineteen males and females intermingled. Several days passed without any signs of engorgement taking place, during which time the males detached and moved about quite frequently, and it is probable that copulation, which evidently takes place on the host, was necessary before the females began to engorge to any extent.

As the females became nearly engorged they began excreting small drops of white, chalky-like fluid. The first replete female left the host on April 26, after a 17-day attachment period, and nine more dropped between this date and April 30. An ulcer which had been developing at the area where the large cluster of ticks were attached became so serious at this time that the rest of the ticks were removed in order to save the snake. The lot removed were found in all stages of engorgement, from those fully engorged and about ready to detach to several that evinced no signs of repletion except for a slight thickening.

The engorgement period of the adult female seems to be quite variable; during the whole of our rearing experiments with this tick we have found the shortest period to be 15 days and the longest 36 days.

The average adult male when taken from a host was 5 mm. long, 3 mm. wide and was quite flat. It weighed 10.8 mgm., and the predominating color was brown with light ornamentations.

The coloration of an engorged female varied from gray to dark brown with yellowish markings; the scutum which was usually dark brown also having markings of a lighter hue. The integument of the entire body was thickly dotted with small, round, black spots, with a minute integumental pore in the center of each spot.

Altho these ten females were all apparently fully replete the weights and measurements varied considerably as shown by the following table:

TABLE 1.—WEIGHTS AND MEASUREMENTS OF ENGORGED FEMALES

Tick	Weight, Gm.	Length, Mm.	Width, Mm.	Height, Mm.
1	1.6845	19	14	9
2	1.5259	20	13	8
3	0.7175	16	10	7
4	1.6957	21	14	10
5	0.6763	15	9	6
6	1.2876	19	13	8
7	1.4980	21	13	8
8	0.9103	18	12	7
9	1.4776	20	13	8
10	1.6392	22	14	8

These ten females were placed in separate petri-dishes consecutively numbered and kept on a slightly darkened shelf out of all direct sunlight. During the first 2 or 3 days after dropping from the host, small quantities of the same chalk like fluid, discharged during the few days prior to dropping, was excreted by each female. Beginning within a few hours after dropping, and with some of the individuals extending up until several days after oviposition began, a small globule of serous like fluid was noticed issuing from each of the tiny pores located within the small black spots with which the integument was thickly dotted.

The period of preoviposition was quite short; the number of days elapsing between the dropping of the ticks to the beginning of oviposition is given below:

TABLE 2.—PREOVIPOSITION PERIODS

Tick No.	1	2	3	4	5	6	7	8	9	10
Days	5	5	5	7	6	4	4	4	5	4

When oviposition began the eggs were counted each morning, and those deposited during the preceding twenty-four hours were removed to a separate petri-dish. As oviposition continued and the females became depleted, the yellowish brown patterns on the dorsal surfaces became lighter in color and more pronounced.

The following table shows the oviposition periods and the number of eggs deposited by each tick daily:

TABLE 3.—DAILY OVIPOSITION

Date, May	Number of Eggs Deposited by Each Tick									
	1	2	3	4	5	6	7	8	9	10
1	406									
2	832	291	501			209	464			
3	468	720	640			631	733	533		
4	801	681	544		291	670	777	503		32
5	614	746	401	187	294	516	725	574	384	404
6	473	556	314	396	356	563	652	542		504
7		546	410	582	314	651	633	568		859
8		520	261	612	315	529	643	486		682
9		586	215	906	230	420	595	404	509	510
10		509	170	582	193	401	551	331	744	491
11		425	116	645	139	311	419	278	884	311
12		424	69	721	48	290	359	130	642	399
13		400	46	502	9	236	194	107	745	481
14		329	31	402		143	243	61	694	523
15		231	20	384		137	203	53	388	539
16		205	12	256		73	98	32	343	329
17		155	6	273		41	86	28	264	275
18		135	2	235		22	71	14	200	181
19		88	7	101		5	42	11	113	248
20		48		73			34	6	71	189
21		46		4			20	8	64	53
22		47					12	2	9	
23		21					7	2		
24		14		10			3			
25		6								
26		5		7						
Totals	3,594	7,684	3,765	6,878	2,189	5,848	7,564	4,673	6,054	7,010

The shortest incubation period of these eggs was thirty-eight days, and the longest forty-seven days.

Thruout this series of rearing experiments all the ticks were kept in the shade between two open windows. The temperature thruout the period during which these observations were conducted is given below.

TABLE 4.—AVERAGE TEMPERATURES PER MONTH

Months	Average Maximum °F	Average Minimum °F	Average Mean °F
September	85.4	73.3	79.4
October	82.8	73.2	78
November	83.8	72.3	78.1
December	86.2	72	79.1
January	86.6	70	78.3
February	86.9	69.4	78
March	87.8	72.1	80
April	88.4	72.2	80.3
May	85.2	73.4	79.3

No experiments were made to determine whether or not this tick in its various stages would attach to warm blooded hosts except in one instance when twenty larvae were placed in an uncovered pill box applied to the arm of the writer. This box was held with elastic bands for over 5 hours, but none of the larve attached during that time.

A few tests were made to determine the longevity of *A. dissimile* in the different stages of development. Of a number of larvae that were placed in a test tube on November 18, 1916, and allowed to remain perfectly dry about 5 per cent. remained alive for 101 days without any moisture. When confined in a large stender dish containing sand which was occasionally moistened some of the larvae lived for a period of 228 days. Nymphs when placed in a fairly damp situation remained alive for 162 days, but it was noticed that when placed in surroundings damp enough to cause the growth of molds that the nymphs died in less than 10 days. The greatest longevity period for unengorged females in the presence of moisture was 147 days.

No detailed observations were made to determine the length of time that adult males remained on a host, but at the present time a *Boa imperator* at the laboratory has two adult males attached to it that have been in situ for over 7 months. They have remained attached at apparently the same place during the whole of that time, regardless of the host shedding its skin several times during their attachment. This seems to be contrary to their habits when females are also present on a host.

In order to determine the length of submersion compatible with the life of this species a number of unengorged females were placed in a jar of water. They soon sank to the bottom and in about two hours became motionless. A few were removed each day to see if they were alive. When first taken from the water they always remained without motion and appeared to be dead for several hours, but if placed in the sunlight or other warm situation they became very

active at the end of this time. The last female was taken from the water on the seventh day of submersion and was found to be alive.

When a large number of adults are present the habit of attaching in clusters often causes the death of the host when the latter happens to be a snake. We have had several specimens of serpents die from the effects of tick infestation when an excessive number was applied.

Usually the snake did not seem to mind when the ticks attached themselves except in extreme cases. We observed one highly nervous snake become very angry and excited when a female persisted in attempting to attach at the inner edge of the snake's upper lip. The latter shook its head violently and struck repeatedly at the side of the glass jar in an attempt to dislodge its tormentor. No other indications were noticed to show that reptiles and batrachians ever made any attempt to remove the ticks from themselves with their mouths or bite them.

If the skin of a snake, on which a number of ticks have been attached, is examined closely prior to shedding, it will be found to be very rough and covered with small abrasions and dried scabs.

Papers Cited

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CONTRIBUTIONS TO THE STUDY OF PARASITIC PROTOZOA. IV.

NOTE ON SOME MYXOSPORIDIA FROM CERTAIN FISH IN THE VICINITY OF WOODS HOLE *

ROKUSABURO KUDO

The following is a brief summary of observations made on Cnidosporidian parasites of certain fish in the vicinity of Woods Hole in the summer of 1916. Six species of the parasites were found in eighteen species of fish, chiefly of salt water, which came under my observation. The names of the fish, together with those of the parasites, are shown in the following table.

TABLE 1

Species	Number of Fish Examined	Number of Fish Having Parasites	Organs Harboring Parasites	Parasites
Anguilla chrysypa	3			
Bothus maculatus	1			
Centropristes striatus	2			
Esox. sp.	3			
Fundulus heteroclitis Fundulus majalis	78	34	Gill	Myxosoma funduli n. sp.
Menidia sp.	3			
Morone americana	12			
Mustelus canis	1			
Paralichthys dentatus	15	7	Gallbladder	Ceratomyxa drepanosettae Awerinzew
Perca flavescens	30	1	Spleen	Myxobolus pyriformis Thélohan
Phycis tenuis	1	1	Gallbladder	Small number of Myxosporidia in vegetative stage
Prionolus carolinus	12			
Raia erinacea	1	1	Gallbladder	Small number of Myxosporidia in vegetative stage
Rhombus tricanthus	11			
Scomber scrombrus*	20			
Stenotomus chrysops	14	4	Gallbladder	Ceratomyxa sp.
Tautaga omitis	5			
Tautogolabrus adspersus	10			

* It is quite remarkable to note that Fantham and Porter (1912) found 4 out of 25 fish from French waters which harbored a Myxosporidium.

* From the Marine Biological Laboratory, Woods Hole, and the Laboratories of the Rockefeller Institute for Medical Research.

The fish were brought into the laboratory alive. A study of the external characters and the branchial lamellae under a dissecting microscope was followed by a microscopical examination of the liver, spleen, kidney, urinary bladder and gallbladder. The dark field microscope was used to a greater extent than the ordinary microscope.

For the extrusion of the polar filament, I have been using in my recent work chiefly mechanical pressure and alkali. Perhydrol, which was proved to be an energetic reagent for *Nosema bombycis* (1918) was used on the spores of various Cnidosporidia with satisfactory results. Fixing and staining were usually done as described in previous papers, with a few modifications.

Myxosoma funduli nov. spec.

Habitat: The branchial lamellae and connective tissue of the gill-filament of *Fundulus heteroclitis* and *F. majalis.*

The cysts distinguish themselves from the gill as small white spots attached to the surface of the gill (Fig. 2). In the case of heavy infection, it is not uncommon to find many cysts in one line parallel to the free end of the gill (Fig. 1), similar to those observed by Müller (1841, Fig. 7).

The form of the cysts is usually spherical (Fig. 2), the average diameter being about 150μ. The largest one, however, which was encountered, measured 360μ by 264μ. All the cysts found in sections were in the final stage of development, so that young and matured spores only could be observed.

The spore is pyriform (Text figure A, Figs. 3-7). The spore coat, which is usually uniform in thickness, shows seven to ten markings on the posterior half of its surface (Text fig. A, *a, d,* and Fig. 3). A process similar to that of *Myxosoma dujardini* and *Myxobolus toyamai* was found occasionally (Text fig. A, *c*). The spore-membrane is composed of two halves, the line of junction being parallel to the line connecting the two polar capsules (Text fig. A, *b*). It is straight and thickened a little along the line of junction. The average dimensions of the spores are 14μ in length, 8μ in breadth, and 6μ in thickness. The optical cross-section, therefore, is always oval (Fig. 4).

Two polar capsules and the sporoplasm are found in the sporecoat. The former is pyriform in shape, with dimensions of 8μ in length and 2μ in width. The length of the polar filament is 38 to 42μ. Figure 6 shows one of the filaments extruded under mechanical pressure, though not at its full length. Pressure also changes the form of the spore. For this reason, perhydrol is much to be preferred to pressure, as may be seen from a comparison of figures 5 and 7.

The sporoplasm is granular in structure. Two nuclei were detected in stained preparations (Text fig. A, *d*). In fresh preparations the

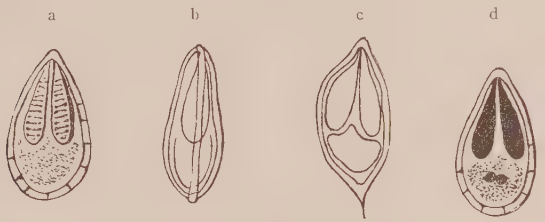
faint outline of a vacuole-like structure was occasionally observed in the sporoplasm. No iodophile vacuole, however, appears when the spore is treated with iodine water, iodine alcohol, or Lugol's solution.

Hahn (1913, 1917) described *Myxobolus musculi* found in the integument, muscles, and gills of fish of the same species in the same locality. During my examination I failed to encounter any parasites in the integument.

The spore of *Myxobolus musculi,* according to Hahn, is 14.3μ long and 6μ wide and has two polar capsules (2 by 0.5μ). Moreover, it has an iodophile vacuole in the sporoplasm and has no marking on the coat. He proved by an infection experiment that the Myxobolus found in the gill and that found in the muscle of Fundulus were the same, though he seems to have noticed some different characters, as for example, a difference in the form of the parasite.

Linton described a Myxosporidian found in the integument of *Cyprinodon variegatus* from the same locality, which was also observed and described by Gurley as M*yxobolus lintoni* Gurley. The form of

TEXT FIG. A



the spore of the species mentioned is somewhat similar to the present form, the latter, however, being narrower at the anterior half than the former. The dimensions given by Linton and Gurley are: length 13.9μ, breadth 11μ and thickness 8μ. Gurley detected an iodophile vacuole in the sporoplasm; this was not the case with the form in question.

The absolute absence of any iodophile vacuole in the present species leads me to describe it as belonging to the genus Myxosoma (Thélohan), which Gurley included in the genus Chloromyxum.

Of the two species hitherto known, *Myxosoma ambiguum* Thélohan is quite different from the one in question. *Myxosoma dujardini* has a spore similar in size and form to the present form but without the marking on the coat. Moreover, the spore-coat of the species above-mentioned is typically more thickened at the anterior end than in the one I observed. There is also a difference between the polar filaments of the two forms.

It is apparent from my description of the species that it seems to be the same as that described by Hahn found in the gill of fish of the

same kind. I propose for it, in accordance with my observations, the name *Myxosoma funduli.*

Ceratomyxa drepanopsettae Awerinzew

Habitat: The gallbladder of *Paralichthys dentatus.*

Seven out of fifteen individuals of about 30 cm. in length harbored the parasite.

Fantham and Porter (1912) made an observation on the effect of Myxosporidia upon the bile and gallbladder of fish. My observations are somewhat similar to the results mentioned by them. The wall of the infected gallbladder was usually thick and opaque. In this connection it may be interesting to mention one of my previous papers (1916). In the case of *Acheilognathus lanceolatum,* the wall of the gallbladder, highly infected with *Zschokkella acheilognathi* Kudo, was found rather thinner and more transparent in some cases than the normal ones, so that the parasites in the bladder and the duct could easily be seen from the outside. On the other hand, it was not rare to find an opaque gallbladder without any parasite in it. In two instances the gallbladder was only about two-thirds of that of other infected fish of similar length.

The bile of the normal fish was clear and greenish, while that of the infected ones was pale yellowish with a large amount of the floating mass, made up chiefly of degenerating epithelium, in which the parasites were found. The vegetative form found in the bile varies greatly in size and form, being sometimes slender and somewhat angular with three or four long fine pseudopodia, and sometimes flat and round, with or without pseudopodia (Figs. 8 to 11). It is not rare, however, to see specimens with a number of fine pseudopodia on all sides of the body (Fig. 8). Some of the psuedopodia attain a length of 30μ. Under the dark field microscope, the form changes very rapidly, probably on account of pressure and temperature. The parasites assume a round shape, withdrawing the pseudopodia (Figs. 10 and 11). A large number of very coarse granules fill up the protoplasm very thickly in almost all cases (Figs. 9, 10 and 11), so that differentiation of the protoplasm into ectoplasm and endoplasm could only be made in very young specimens.

Spores were seldom found in the bile when examined in a fresh condition. It was found, however, that if the bile was kept in small tubes in a refrigerator at about 5 to 15° C. for two or three days, rapid spore-formation took place. These are shown in figures 12 to 14. So far as I could discover, it is always disporous. The dimensions of the spore are: length, 8 to 10μ, breadth 64μ. The round polar capsules have a diameter of about 6μ. Owing to the scarcity of spores, my observation lacks details.

Of all the Ceratomyxa described up to the present time, *Ceratomyxa drepanopsettae* Awerinzew is nearest like the one under discussion. Awerinzew described the species as found in the gallbladder of *Drepanopsetta platessoides*. Later it was found by Auerbach in the gallbladder of *Pleuronectes platessa, P. flesus, Hippoglossus vulgaris,* and *Hippoglossoides limandoides*.

The dimensions are not given by Awerinzew. But the nuclear change in the vegetative form of his illustrations is very much like that of the present species. The probable dimensions of the spore given by Auerbach are about 12 to 14μ in length and 56μ in width, the diameter of the polar capsule being about 4 to 6μ. The form of the spores illustrated by both authors is exactly like the present form. I conclude, therefore, that the two forms are identical.

Myxobolus sp.

Habitat: Spleen of *Perca flavescens*. Only one case of slight infection was encountered.

A very small number of isolated spores were found both in smear and section preparations. The form of the spore is ovoidal, attenuated at the anterior end. The coat is uniformly thick, having one polar capsule and a sporoplasm in which an iodophile vacuole could easily be detected. Two nuclei of the same size (about 2μ) were usually present in the sporoplasm. The dimensions are as follows: Length and breadth of the spore 18 to 20μ and 8μ, respectively. The polar capsule is 7 to 9μ long and 3 to 6μ wide.

The species in question is probably identical with *Myxobolus pyriformis* Thélohan described by him as found in the branchiae and spleen of *Tinca tinca* and kidney of *Misgurnus fossilis*.

I want to express my thanks to Dr. Noguchi for allowing me to carry on these observations in his laboratory.

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Explanation of Plates

All the figures were photographed from fresh preparations under dark field illumination.

Plate I. *Myxosoma funduli* n. sp.

Figs. 1 and 2. The infected gills.

Fig. 3. A group of spores.

Fig. 4. Optical cross section of a spore.

Figs. 5 and 6. Spores treated with perhydrol, showing the extruded filaments.

Fig. 7. A mechanically pressed spore with one of the filaments extruded.

Plate II. *Ceratomyxa drepanopsettae* Awerinzew

Fig. 8. A relatively young vegetative form with fine pseudopodia.

Fig. 9. A large form, showing the outline of the nuclei and the granules.

Fig. 10. A myxosporidium with a pseudopodium at one end of the body.

Fig. 11. The same specimen after 20 minutes, withdrawing the pseudopodium.

Figs. 12-14. Spores found in the bile after it had been kept in the refrigerator for three days.

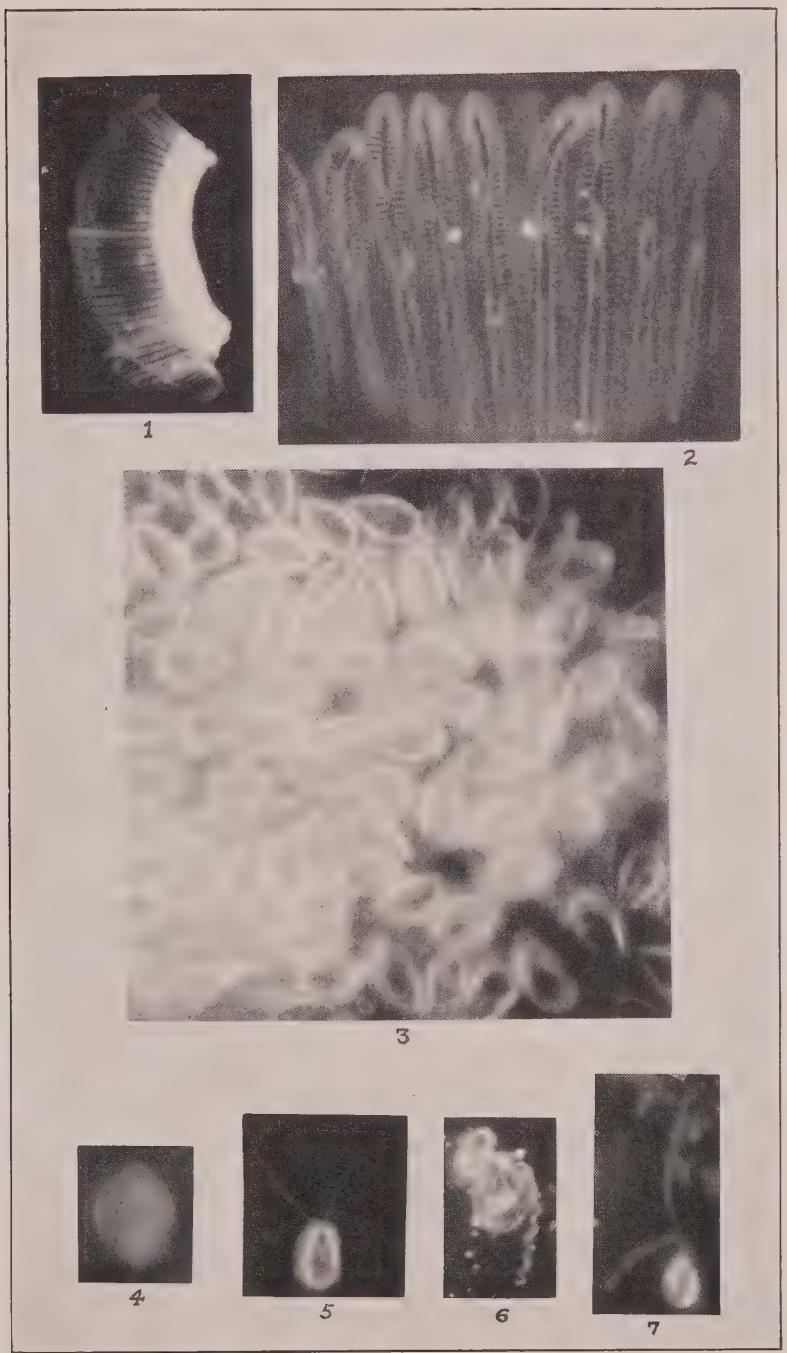

PLATE I

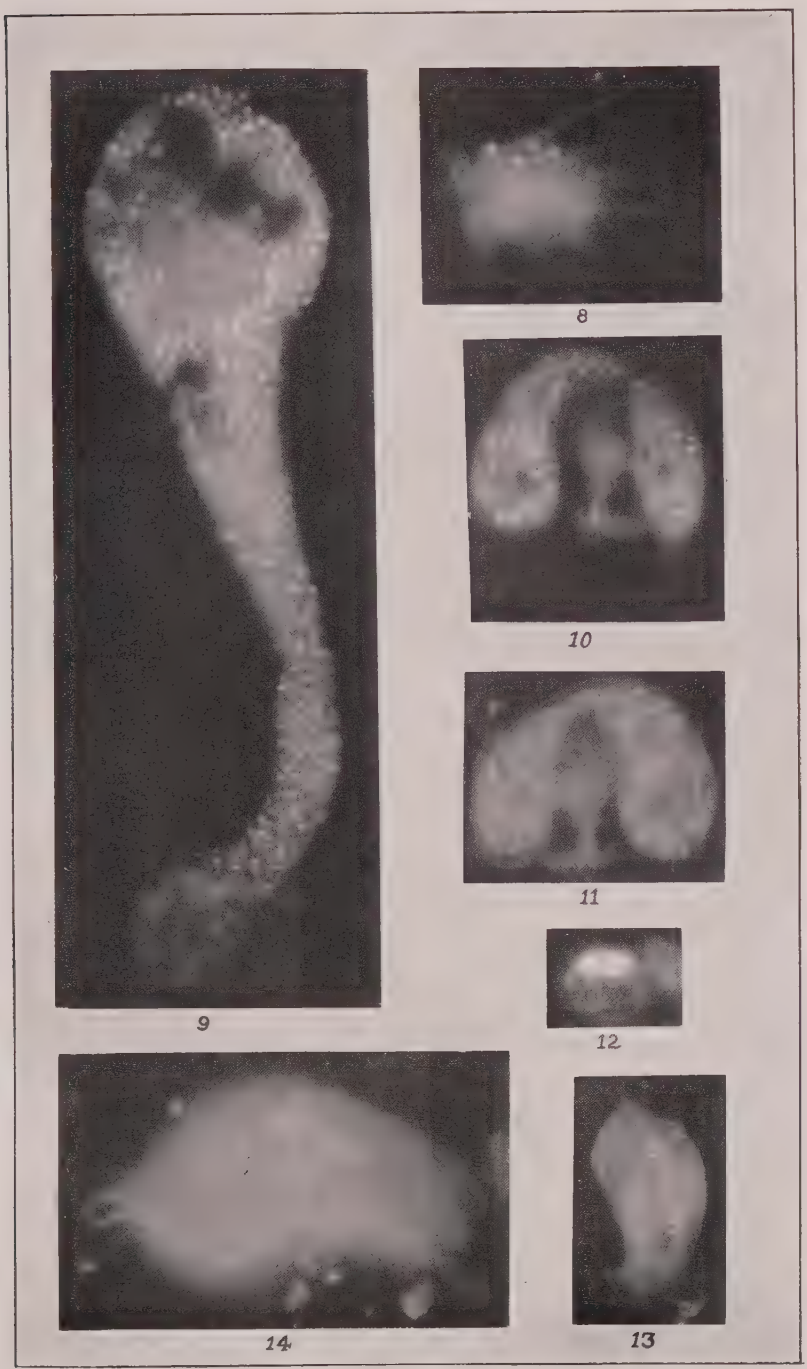

PLATE II

ACANTHOCEPHALA OF THE SUBFAMILY RHADINORHYNCHINAE FROM AMERICAN FISH*

H. J. Van Cleave

But two species of Acanthocephala have, to the present time, been definitely ascribed to the genus Rhadinorhynchus. *Echinorhynchus pristis* Rud. was the original species for which Lühe (1911) created this genus. One year later he added another species to the genus by his description of *R. horridus* from Egypt. The older species has been reported as parasitic in fishes from various parts of the world. The descriptions given in these scattered reports differ so radically that it seems improbable that they could all apply to a single species. Here, as in other genera of Acanthocephala, it seems obvious that the older workers, recognizing the cardinal points which in modern classification have been accepted as indicative of generic value, have failed to observe the less obvious, though significant, differences which serve to separate species. Thus all members of the present genus Rhadinorhynchus have been identified as *E. pristis,* and the descriptions have usually been inadequate to enable more recent workers to recognize the same forms if encountered again. In some few instances the descriptions have been complete enough to permit one to recognize the forms described. Linton's work on *E. pristis* is of the type last mentioned.

In 1891 Linton recorded the occurrence of Acanthocephala which were at least similar to *E. pristis* from the intestine of *Tylosurus acus* (Lacép), and of *Lobotes surinamensis* (Bloch). After acknowledging "perplexity in attempting their identification," Linton tentatively ascribed some of his individuals to the species *E. pristis,* while others he referred to a new variety of that species. To the variety he gave the name *E. pristis tenuicornis.* In later work he remarked upon the presence in what he determined as *E. pristis* from fishes at Beaufort, N. C., of "a circle of hooks at the base of the proboscis which are longer than the other hooks" (Linton, 1908: 89). This "circle" of hooks was briefly mentioned in an earlier paper (1892: 531). In materials studied by the present writer, the spines at the base of the proboscis, though not forming a circle, are very conspicuous. After a comparison of these specimens with data given by Linton the writer is convinced that Linton was at various times dealing with at least two distinct species of the genus Rhadinorhynchus to which he gave

* Contributions from the Zoological Laboratory of the University of Illinois, No. 122.

reference as *E. pristis* and *E. pristis tenuicornis*. Further evidence of this will be presented in a later part of this paper.

In later works Linton described two additional species of Acanthocephala, *Echinorhynchus sagittifer* and *E. medius*, both of which obviously belong near to the genus Rhadinorhynchus. The former of these has been referred to Monticelli's genus Echinogaster, and in the present paper the writer includes the species *medius* in the genus Rhadinorhynchus. The records mentioned above constitute the only cases of Rhadinorhynchus-like forms reported from North America.

TABLE 1

COMPARISON OF R. PRISTIS WITH AMERICAN SPECIES OF RHADINORHYNCHINAE

Form	Proboscis Hooks		Body Spines		Embryos
	Number	Size	Arrangement	Size	
R. pristis (Rud) of Lühe, 1911	14 longit. rows of 26 hooks each	85μ*	Scattered in two fields	110μ*	95×17μ
R. ornatus n.sp. (*E. pristis* of Linton, 1892)	About 24 longit. rows of about 40 hooks each.	50-80μ	Scattered	80μ	60μ long.
R. tenuicornis n.sp. (*E. p. tenuicornis* of Linton, 1892)	14 longit. rows of about 26 hooks each; crescent of spines at base of proboscis	♀40-80μ ♂20μ+	Scattered	♀60-80μ ♂28μ+	60 to 80μ by 12μ
R. medius (Linton, 1905)	About 22 longit. rows of about 20 hooks each	45-60μ	Scattered	30-45μ	75×24μ
Echinogaster sagittifer (Linton)	About 24 longit. rows of 15-18 hooks each	80μ	Collar of scattered spines followed by 18-23 ventral cross rows	Collar 50-60μ Ventral rows 60-70μ	?

*Unfortunately Lühe has not given measurements of the hooks or body spines of *R. pristis*. The measurements given for *R. pristis* above are approximations obtained by finding the values for these structures on the basis of the magnification given with his figures. These can serve as mere approximations, for in checking over other drawings in the same article considerable error in magnification has been found. For example, 95μ is the length given in the text for the embryos of *R. pristis*, while application of stated magnification to the embryo figured gives a value of but 83μ for the length. Embryos usually vary some in length but Lühe's failure to state the range of variability in his measurements makes it impossible to calculate the probable error in his magnification.

Table 1 lists the points of difference and similarity between the forms dealt with in this paper. The writer has created a new species, *Rhadinorhynchus ornatus*, for the forms described by Linton as *E. pristis*. Specimens from the U. S. National Museum, examined by the writer, are apparently identical with Linton's *E. pristis tenuicornis*. After a careful study of these specimens, results of which have added some new data to our knowledge of the structure of the form, the writer has given a description of a new species, *Rhadinorhynchus tenuicornis*. In this connection it is interesting to note that

of the Rhadinorhynchinae but one species is known to Europe and one to Africa, while from the American continent four species representing two genera are now reported.

Genus RHADINORHYNCHUS Lühe 1911

Synonym: Echinosoma Porta 1907 (preoccupied), in part.

Generic Diagnosis.—Acanthocephala parasitic as adults in the intestine of fish. Anterior body region armed with scattered cuticular spines, ensheathed by cuticular folds. Proboscis and proboscis receptacle very long. Ventral proboscis hooks stronger than dorsal. Proboscis receptacle a two-walled muscular sac with the brain located near its middle. Lemnisci long, fingerlike.

Porta (1907: 412) gave the name Echinosoma to a new genus of Acanthocephala which he created to include: *E. gibber* Olss., *E. vasculosus* Rud., *E. miliarius* Zenk., *E. roseus* Mol., *E. pristis* Rud., and several other species. The name Echinosoma is preoccupied and is for that reason not available for this group of Acanthocephala. Furthermore, the forms listed by Porta constitute a heterogeneous group which have but little in common aside from the presence of spines on the body. No species was cited as type of Porta's Echinosoma. On the other hand the first species mentioned in his list was *E. gibber* Olss. which has been quite commonly regarded as a synonym for *E. strumosus*. In 1904 Lühe created the genus Corynosoma with *C. strumosum* as type by original designation. Subsequently a number of new genera have been created which include species cited by Porta for his now disrupted genus Echinosoma. Rhadinorhynchus Lühe 1911, with *R. pristis* (Rud.) as type species, is one of this number. Consequently, Echinosoma Porta 1907 in part, must be regarded as a synonym of Rhadinorhynchus Lühe 1911.

Rhadinorhynchus ornatus nov. spec.

Synonym: *E. pristis* Rud. of Linton, 1892 and 1908. Text figure A.

Specific Definition.—With the characters of the genus Rhadinorhynchus, Lühe, 1911. Probosics armed with from twenty-two to twenty-four longitudinal rows of about forty hooks each. Hooks on proboscis ranging from 50 to 80μ in length. Anterior body region armed with scattered cuticular spines about 80μ long. Embryos about 60μ long.

Host: *Tylosurus acus* (Lacép.), Woods Hole, Mass.

The above definition is adapted from the original description by Linton.

Rhadinorhynchus tenuicornis nov. spec.

Synonym: *E. pristis tenuicornis* Linton, 1892. Figures 1 to 4 and text figure B.

The variety *Echinorhynchus pristis tenuicornis* created by Linton (1892), for what he considered a variety of the European species *E. pristis,* is clearly a distinct species. Table 1 presents the evidence of the distinctness of this and other forms dealt with in this paper. In elevating the variety to specific rank the writer has used the varietal name for the name of this species. Data given by Linton in his original description of the variety omitted several characteristics which are useful in drawing a closer limitation of the species. Fortunately, the present writer has had access, through the government collections, to additional specimens which in all essential details agree with Linton's description. A study of these specimens has made it possible to offer here a more complete description of *R. tenuicornis.*

Specific Definition.—With the characters of the genus Rhadinorhynchus. Proboscis armed with ten to fourteen longitudinal rows of approximately twenty-six hooks each. Proboscis hooks of female 40 to 80μ long; of male near base may be as small as 20μ. A conspicuous crescent of about seven long hooks on the ventral side of the proboscis at the region between neck and proboscis. Body spines of female 60 to 80μ, of male about 28μ. Embryos inside body cavity of female 60 to 80μ long and 12μ wide, with middle membrane drawn out into attenuated polar capsules.

Hosts: Tylosurus acus and *Lobotes surinamensis* at Woods Hole, Mass., and "trout" at Baltimore, Md. The collection of specimens from this last host was made by Hassall in October, 1891. Specimens are on deposit in the Hassall collection of the U. S. National Museum, catalog number 6324.

The anterior body region in this species, especially among the females, tapers considerably to reach the size of the proboscis at the point of insertion with the proboscis receptacle. In many specimens the extremely long proboscis and the anterior region of the body are withdrawn within the body. The proboscis receptacle is so long that in retracting the inverted proboscis toward its base much of the anterior body region also becomes inturned. Linton in 1891 and again in 1905 mentioned the "circle of prominent arcuate hooks" at the base of the proboscis. In *R. tenuicornis* the present writer has found a group of prominent hooks in the same locality, but they take the form of a crescent instead of that of a circle, since in their distribution they are restricted to the ventral surface of the proboscis. This arrangement in the form of a crescent is shown clearly even in specimens which have the proboscis and anterior body region inturned (Fig. 2).

These hooks differ in appearance from the remainder of the proboscis hooks and also differ from the body hooks. They present a peculiar granular appearance in stained whole mounts.

Rhadinorhynchus medius (Linton)

Synonym: *Echinorhynchus medius* Linton, 1908.

This species was described by Linton (1908:88) from Bermuda fishes. In his description he called attention to the fact that "this species is near *E. pristis,* in external appearances," but in listing the points of difference he omitted several of the most essential. The present writer has reexamined the type material deposited in the U. S. National Museum and has been able to corroborate Linton's original description as far as it goes. A brief summary of the diagnostic characters of the species follows:

Specific Definition.—With the characters of the genus Rhadinorhynchus. Proboscis linear to fusiform, armed with about twenty-two longitudinal rows of about twenty hooks each. Hooks near base (basal two or three of each row) about 45μ long, remainder of hooks fairly uniform in size, about 60μ long. Hooks deeply embedded in cuticula, recurved, stout. Neck smooth, conical. Body spines 30 to 45μ long; extend on ventral side of body from just back of neck to about one-third the length of the proboscis receptacle; on dorsal surface extend only about one-half the distance of ventral. Embryos 75μ long by 24μ wide.

Host: Mycteroperca apua, in intestine. Locality, Bermuda Islands. Larvae in cysts on viscera of various fishes. Types deposited by Linton in U. S. National Museum, catalog number 5796.

Genus ECHINOGASTER Monticelli 1905

Synonyms: Echinorhynchus in part. Echinosoma Porta, 1907, in part.

Monticelli (1905:11) in a footnote created the genus Echinogaster giving a six-word diagnosis and designating no type for this or for either of the other two genera (Pomphorhynchus and Chentrosoma) created at the same time. Porta (1907:413) reduced Echinogaster to a subgenus of his newly created genus Echinosoma, and referred *E. sagittifer* of Linton to Echinogaster. The name Echinosoma is preoccupied and can consequently not be accepted as a name for Porta's genus. Furthermore, the present writer is definitely of the opinion that the genus Echinogaster was erroneously reduced to subgeneric rank, and here proposes elevating it again to full generic standing. Lühe (1912:278) called attention to the close relationship which exists between members of the genera Rhadinorhynchus and

Echinogaster and proposed that a new subfamily, the Rhadinorhynchinae, be erected in recognition of this fact. Many points in the structure of the members of the genus Echinogaster are unknown at the present time, consequently it seems advisable to offer as a generic diagnosis only those points which serve as a ready means of separating Echinogaster from Rhadinorhynchus. A more complete diagnosis can be given only upon a restudy of forms belonging to this genus.

Generic Diagnosis.—Rhadinorhynchinae with ventral cross rows of body spines.

Echinogaster sagittifer (Linton, 1889)

Synonyms: *Echinorhynchus sagittifer* Linton, 1889. *Echinosoma* (*Echinogaster*) *sagittifer* (Linton) Porta, 1907.

Specific Definition. — Rhadinorhynchinae with characters of the genus Echinogaster. Proboscis clavate, bluntly rounded in front, increasing slightly for a short distance back from the tip, then narrowing gradually to the base; armed with about twenty-four longitudinal rows of about fifteen to eighteen hooks each. Longest proboscis hooks about 80μ long. Body spines arranged in two distinct groups — a collar of spines 50 to 60μ long on the body region just behind the neck, and eighteen to twenty-three series of ventral transverse rows of spines each containing from six to twenty-four sagittate spines about 60 to 70μ long. Measurements of embryos not given.

Host: Rachycentron canadus, in intestine, at Beaufort, N. C. Larvae encysted in mesentery and viscera of various marine fishes.

Key to the species of Rhadinorhynchinae from American fish.

1 (6) Rhadinorhynchinae with scattered body spines.....2
2 (5) Body spines of females over 60μ long.....3
3 (4) Proboscis with less than sixteen longitudinal rows of hooks ..... *Rhadinorhynchus tenuicornis*
4 (3) Prosboscis with more than twenty longitudinal rows of hooks ..... *Rhadinorhynchus ornatus*
5 (2) Body spines of female less than 50μ long..... ..... *Rhadinorhynchus medius*
6 (1) Body spines on ventral surface arranged in cross rows.... .....*Echinogaster sagittifer*

SUMMARY

A new species, *Rhadinorhynchus ornatus,* is created for *E. pristis* of Linton, 1891.

Rhadinorhynchus tenuicornis nov. spec. is created for Linton's variety *E. pristis tenuicornis.*

Echinosoma Porta, 1907, is preoccupied and in part is to be considered as a synonym of Echinogaster Monticelli, 1905.

Echinorhynchus medius Linton, 1908, is assigned to the genus Rhadinorhynchus.

A key is given to the Rhadinorhynchinae of America including three species of the genus Rhadinorhynchus and one species of Echinogaster.

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Explanation of Figures

Text Figures A. and B. showing distinctive differences in proboscis armature of *R. ornatus* and *R. tenuicornis.*

(A.) *R. ornatus,* median region of proboscis of female; × about 150. From Linton, 1891, Fig. 33.

(B.) *R. tenuicornis,* portion of proboscis of male, × about 150. From Linton, 1891, Fig. 53.

Explanation of Plate

All drawings made with the aid of a camera lucida. Magnification is indicated by the reference line accompanying each figure which has the value of 50μ.

Rhadinorhynchus tenuicornis nov. spec.

Abbreviations used: *a,* anterior; *br,* brain; *lem,* lemnisci; *p,* posterior; *pr,* proboscis receptacle.

Fig. 1.—Anterior body region of male with partially inverted proboscis. Basal crescent of hooks is wanting in this specimen. The proboscis had been slightly damaged at the point where they should occur.

Fig. 2.—Optical section of female in anterior ventral region of body showing group of hooks at base of inverted proboscis.

Fig. 3.—Surface view of anterior body region of female with proboscis completely inverted.

Fig. 4.—Embryo from uterus of mature female.

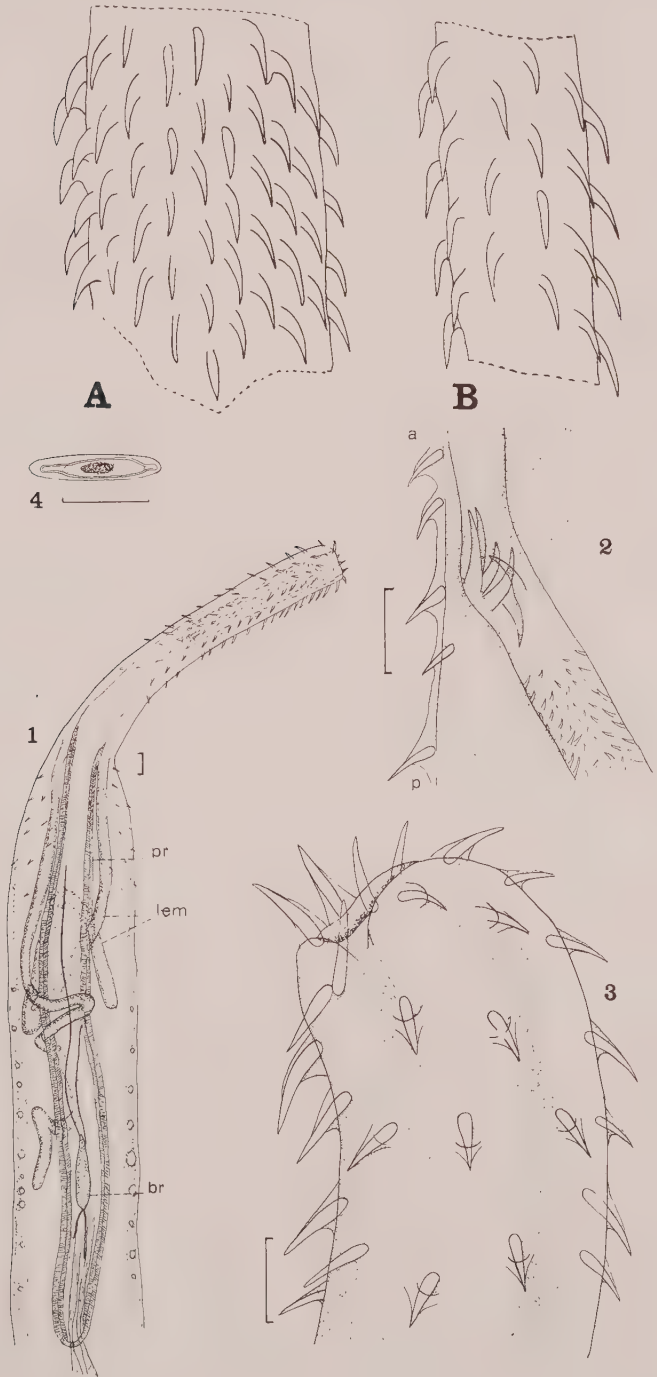

PLATE III

NOTES ON TWO SPECIES OF NEMATODES [*GONGYLONEMA INGLUVICOLA* RANSOM, 1904, AND *CAPILLARIA STRUMOSA* (REIBISCH, 1893)] PARASITIC IN THE CROP OF CHICKENS

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In making postmortem examinations of Philippine chickens, two species of nematode worms have been found in the walls of the crop. Both of them live in winding burrows in the mucosa and are never found free in the lumen. The larger of the two forms which was found in about 40 per cent. of all the chickens examined, has been identified as *Gongylonema ingluvicola* Ransom, 1904. The second and more slender species I have recognized as *Capillaria strumosa* (Reibisch, 1893). It was found in about 30 per cent. of the chickens dissected.

Gongylonema ingluvicola Ransom, 1904

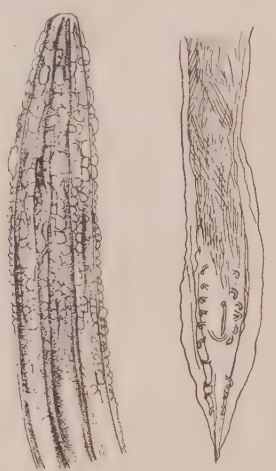
This species was described by Ransom from the crop of a chicken from Key West, Florida. It is the only species of this genus which has been described from birds. On superficial examination of my material I was inclined to believe that the Philippine species was different from *ingluvicola;* however, after a careful study of a number of specimens and a comparison of the measurements of the different parts of the body with Ransom's description, I do not feel justified in separating this form from that species.

The body is white in color and the cuticula is annulated, the annulations measuring 10 to 11μ in breadth in the females and 6 to 7μ in the males. The arrangement and extent of the "cuticular bosses" at the anterior end of the body in my specimens (see Fig. 1) is almost identical with Ransom's description and figure. The "transversely elongated, large, plate-like shield" through which the excretory pore opens seems, however, to be considerably wider in my specimens than is indicated in Ranson's figure, and projects considerably from the surface of the body. The lateral membranes, which start a short distance back of the cervical papillae, are short and inconspicuous.

The following table shows graphically the measurements of Ransom's original specimens as compared with the Philippine form. My measurements are the maximum and minimum of seven adult females and the same number of males.

TABLE 1

Gongylonema ingluvicola	Male		Female	
	Ransom	Wharton	Ransom	Wharton
Length of body	17-19 mm.	17-20 mm.	32-45 mm.	40-55 mm.
Breadth of body	250μ	224-256μ	400-490μ	320-420μ
Extent of cuticular bosses	575-680μ	480-496μ	1.3-2.6 mm.	1-1.36 mm.
No. of rows of bosses	16	?	20-24	20-24
Distance of cervical papillae from anterior end	100μ	100-125μ	135μ	120-150μ
Distance of excretory pore from anterior end	300μ	368-400μ	450μ	450-480μ
Length of anterior part of esophagus	280-400μ	400-480μ	540μ	575-608μ
Length of posterior part of esophagus	3.2-3.3 mm.	3.2-3.3 mm.	5-6 mm.	4.5 mm.
Distance of anus from tip of tail	225-275μ	264-275μ	165-215μ	240-288μ
Distance of vulva from tip of tail			2.5-3.3 mm.	3-3.5 mm.
Length of vagina			13 mm.	11-14 mm.
Eggs in vagina			50 x 36μ	52.9 to 56.7 x 37.8μ
Width of tail, including alae	225μ	208-240μ	.....	.....
Length of right ala	500-575μ	560-736μ	.....	.....
Length of left ala	600-700μ	720-800μ	.....	.....
Left spicule	17-19 mm. by 9μ	17-19 mm. by 7-9	.....	.....
Right spicule	100 x 15μ	120 x 20μ	.....	.....



1 2

Fig. 1.—Lateral view of anterior end of female *Gongylonema ingluvicola*.
Fig. 2.—Posterior end of male showing regular arrangement of genital papillae and the right spicule. (Drawings by Castro. Camera lucida outlines.)

The number and arrangement of the genital papillae of the male, which is generally very regular in members of this genus, show marked variations in this species. Ransom says "The number of genital papillae is rather variable and they are not symmetrically arranged. In the specimens examined the number of preanal papillae on the left side was 5 to 7, on the right side 4 to 4, and the number of postanal papillae 3 to 4 on the left side, 4 on the right side." I have carefully studied the papillae in 14 of my specimens and found the number as follows:

TABLE 2.—ARRANGEMENT OF ANAL PAPILLAE

	Preanal		Postanal		
	Rt.	Lt.	Rt.	Lt.	Total
No. 12	7	6	4	4	20
No. 1	6	6	4	4	20
No. 2	6	6	4	4	20
No. 4	6	6	4	4	20
No. 10	6	6	4	4	20
No. 11	6	6	4	4	20
No. 14	6	6	4	4	20
No. 5	5	5	5	5	20
No. 6	5	5	5	5	20
No. 3	5	5	5	4	19
No. 9	5	5	4	4	18
No. 7	6	2	4	4	16
No. 8	4	6	3	2	15
No. 13	0	7	3	3	13

In Specimens 1, 2, 4, 10, 11, 14, 5, 6 and 9 the papillae are arranged symmetrically in pairs (see Fig. 2). In the other specimens which appear to be asymmetrical, this appearance is the result of the suppression of one or more papillae on a side as in Nos. 3, 7 and 8, or the addition of an extra papillae anteriorly as in No. 12. It would require the study of a much greater series than I have in my possession at the present time to determine whether or not ten pairs of papillae is the normal number, but the preponderance of this number and arrangement in my series is, I think, worthy of note. The slightly greater length, in my specimens, of the lateral alae as shown in Table 1 can be accounted for by the greater body length. The size and shape of the spicules is practically the same as in Ransom's specimens. The extreme length of the left spicule is a characteristic which easily distinguishes this form from other species of the genus.

Geographical distribution. All of my specimens have come from chickens which were raised in or very close to Manila, so I am not able to state whether this form is of general distribution in the Islands.

Capillaria strumosa (Reibisch, 1893)

This species has been reported from *Phasianus colchicus* and *Gallus domesticus*. On account of their extreme slenderness and the tortuous windings of their burrows it is very difficult to obtain whole specimens. I have several whole females, but have not succeeded in obtaining any complete males.

The length of the females runs from 40 to 55 mm., and they are 100 to 120μ thick. The males are estimated to be from 17 to 25 mm. long and 70 to 80μ in thickness. The cuticula is striated transversely and the cephalic extremity is surrounded by the characteristic cuticular dilation. The oesophagus in the female is from 7 to 8 mm. long and the vaginal opening is situated just at the end of the oesophagus. The eggs in the vagina measure 60 to 64μ by 26 to 28μ. The male is provided with two projections around the anal opening.

Neither one of these forms is often found in any great numbers in the chickens I have examined, and as far as I could see they do not cause any pathological conditions of importance.

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TWO NEW NEMATODES COMMON IN SOME FISHES OF CAYUGA LAKE*

MEYER WIGDOR

Very little work has been done in this country on the nematode parasites of fishes. Suitable monographs are available on the nematodes of rodents, ruminants and some domesticated animals, but when the identification of fish nematodes is attempted, resort must be had to foreign literature such as the key to the nematodes in Brauer's Süsswasserfauna Deutschlands, Railliet and Henry's many valuable papers, etc. Ward's recent compilation (1918) of freshwater nematodes in "Ward and Whipple's Freshwater Biology," is a very important and valuable aid in the identification of these forms and will undoubtedly give an added impetus for further study along these lines, but much work remains to be done before a really comprehensive monograph on nematodes from freshwater fishes will be possible.

That the study of fish nematodes presents a large and little investigated field in this country is evidenced by the number of new genera and species recently established by workers in this group of fish parasites. Ward and Magath (1917) describe eight new species of nematodes from freshwater fish, three constituting new genera and five agreeing sufficiently with European forms to be listed in already existing genera. The two new species described in this paper both fall within existing genera, one being placed in the genus Rhabdochona in the family Thelaziidae of the superfamily Spiruroidea, which superfamily seems to hold a very prominent place among the parasites of freshwater fishes, and the other being placed in the genus Hysterothylacium in the family Heterocheilidae of the superfamily Ascaroidea.

Rhabdochona cascadilla Wigdor nov. spec.

Rhabdochona is a new genus created by Railliet (1916) in the family Thelaziidae of the superfamily Spiruroidea. He characterizes the family as comprising forms possessing a head, either naked or provided with cuticular expansions or with a cup-shaped covering; the mouth without lips or only two in number and followed generally by an elongated vestibule or a short buccal capsule.

He characterizes the genus as follows: Mouth with two lips, limiting a funnel-shaped cavity which is supported by longitudinal cuticular ribs. Esophagus of medium length and with two distinct parts. Male

* Contribution from the Entomological Laboratory of Cornell University.

with a conical tail, pointed and recurved. No caudal alae; numerous simple preanal and postanal papillae. Two unequal spicules. Female with a straight conical, elongated tail. Vulva towards the posterior end of the body. Uteri divergent. Habitat: intestine of freshwater fishes. Type species: *Dispharagus denudatus* Duj. 1845.

In Cascadilla creek, especially at Dwyer's pond, *Rhabdochona cascadilla* was found to be especially common in the small intestine of the horned dace, *Semotilus atromaculatus* (Mitchell) and the cayuga minnow, *Notropis cayuga* (Meek), two minnows especially common in this tributary to Lake Cayuga.

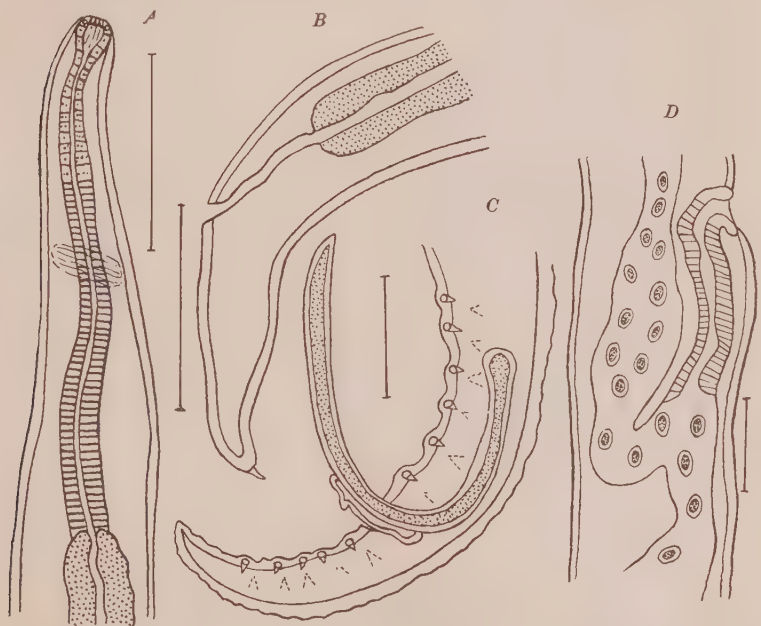
This new species may be briefly characterized as follows: Body filiform, cylindrical, attenuated at anterior end. Head truncated, somewhat rounded and smooth. Mouth possessing two lips terminating a funnel-shaped cavity which is supported by longtiudinal cuticular ribs bearing two small, somewhat conical, papillae (Fig. 1). Esophagus distinctly short and made up of an anterior and posterior portion, the former being approximately one-third the length of the latter.

Male: 3.01 to 4.11 mm. in length and 0.096 to 0.104 mm. in width at widest part. Length of esophagus 0.24 mm. Distance of nerve ring from anterior extremity 0.115 mm. Spicules very prominent. Large spicule 0.04 mm. in length, pointed and very flexible and generally U-shaped when protruding from body. Small spicule slightly more than one-fifth as long as the large spicule and provided with a blunt, cap-like distal portion. Tail conical, subacute and recurved. Six pairs of preanal, one pair of adanal and five pairs of postanal papillae (Fig. 2).

Female: 6.80 to 9.28 mm. in length and 0.096-0.128 mm. in width at widest part. Young immature females 3.8 to 4.06 mm. in length and 0.08 to 0.096 mm. in width. Vulva a transverse slit in posterior portion of the body about five-eighths the total body length from anterior extremity. Ovijector extends 0.18 mm. posteriad of the vulva. Uteri divergent (Fig. 3) and very voluminous, full of developing ova 32 by 16μ in diameter, and filling up approximately three-quarters of the body cavity. Uterus bifurcates 0.272 mm. posteriad of the vulva, one branch extending anteriad, the other posteriad. Anterior ovarian tube reaches 2.42 mm. anteriad of the vulva, and then loops posteriad for a distance of 1.019 mm. Posterior ovarian tube extends to a point 0.586 mm. from posterior extremity and then loops about and extends anteriad for a distance of 1.764 mm. Anus 0.06 mm. from posterior extremity. Tail characteristically very blunt, terminating in a spine-like process and usually bent back at an angle to the body (Fig. 4).

Hysterothylacium cayugensis Wigdor nov. spec.

A nematode found very commonly in the pike, *Esox lucius* L, and much less commonly in the bullhead, *Ameirus nebulosus* (LeSueur), in the waters of Lake Cayuga, in all probability falls in the new genus described by Ward and Magath (1917) as Hysterothylacium. This is in the family Heterocheilidae which they characterize as follows: "Body without anterior tunic but with narrow lateral alae ("wings"). Lips three, not prominent. Esophagus arising from anterior end of



All figures are camera drawings. The reference line is 100μ long in each case.

Fig. 1.—*Rhabdochona cascadilla; A,* Anterior extremity. *B,* Posterior extremity. *C,* Posterior extremity of male showing specules and papillae. *D,* Female, showing vulva, ovejector and divergent uteri.

intestine, directed posteriad." These workers have found the males only, the females being unknown, while the large number of specimens I have obtained are all unfertilized females.

Hysterothylacium cayugensis may be briefly characterized as follows: Length, 15 to 20 mm.; width, 0.14 to 0.19 mm. Three pairs of well-defined lips (Fig. 5). Head without anterior cuticular expansions. Esophagus long, averaging 2.35 mm. in length and 0.08 mm. in width. Distance of nerve ring from anterior extremity 0.21 mm. The esophagus is followed by what appears at first sight to be an

esophageal bulb, but on closer examination this seems to be a rotund dilation of the cecum which arises from the anterior portion of the intestine and extends posteriad as a cecum. This bulb-like expansion of the cecum is apparently glandular in nature, which would preclude the idea that this is an esophageal bulb. The expansion measures 0.128 mm. in diameter, while the cecum, including the dilation, is quite long, measuring 0.68 mm. in length and 0.026 mm. in width. Broad lateral alae (Fig. 6), width nearly one-fourth the diameter of the body, extend from base of lips to base of esophagus or farther. Body with marked transverse striations 2μ apart.

Male unknown.

Female with vulva in anterior portion of body, at a point approximately two-fifths of the length of body from the anterior end. Ovijector quite long, extending 0.549 mm. posteriad of the vulva. Uterus forks (Fig. 7) 0.588 mm. posteriad of the vulva to form two divergent uteri, one branch extending anteriad, the other posteriad. Uteri long, looping transversely and diagonally (Fig. 8) through a large portion of the body cavity. Posterior ovarian tube extends to 0.14 mm. from the anus, which in turn lies 0.252 mm. from posterior extremity. Posterior extremity usually very acute.

Although this species has been placed in the genus *Hysterothylacium,* it differs essentially from Ward and Magath's description of the genus in the following particulars: There is no esophageal bulb, but a glandular rotund expansion of the cecum suggesting a bulb; and the cecum is quite long instead of short. In *H. brachyurum,* Ward and Magath's species, the cecum is approximately one thirty-third of the total length of the body; in *H. cayugensis,* Wigdor's species, it is approximately one twenty-fifth of the total length. The lips are well-defined in *H. cayugensis.* Ward and Magath (1916) state that the lips are not prominent in their species.

In assigning this species to the genus *Hysterothylacium,* the writer has assumed that in view of the features in common, it is possible that what Ward and Magath regard as an esophageal bulb, and what I regard as a proximal dilation of an intestinal cecum, are identical structures. If this assumption is correct, the two species are congeneric. Their specimens being all males and mine all females, the two might even have been regarded as identical species, if it were not for the fact that their males attained the size of 32 mm., while the largest of my females attained a maximum length of 20 mm. Since the female nematode is almost invariably larger than the male of the same species, this is excellent evidence of the specific distinctness of *H. cayugensis.* If, however, Ward and Magath are correct in their interpretation of the structure as an esophageal bulb, the form

described here must be transferred to another genus and may require the erection of a new genus.

Besides the mature worms, immature forms in the larval stage were obtained from the pike. They were 6 to 10 mm. in length and approximately 0.1 mm. in width, all of them as far as could be determined, being immature females.

Further studies on the minnows and small immature fish of Cayuga Lake disclosed forms which are undoubtedly the early larval stages of this worm. The presence of lateral alae, and a posteriorly directed intestinal cecum, with a spherical anterior expansion, and mouth parts bearing a strong resemblance to the mature form, shows that it is the same worm that reaches maturity in the pike and bullhead, after being ingested by the latter in eating the intermediate hosts. The host fishes

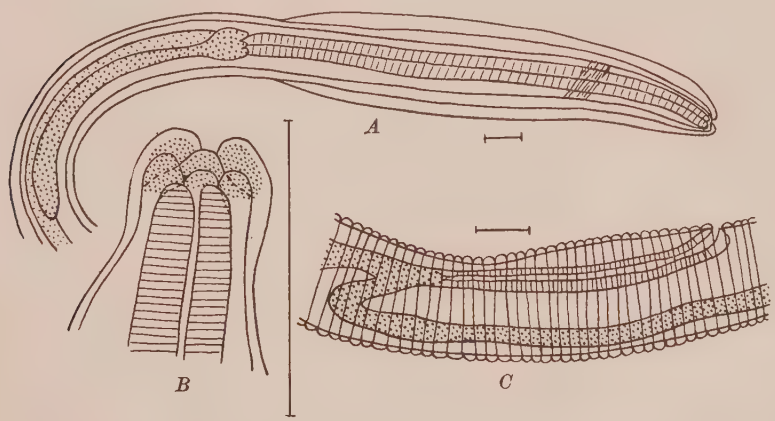


Fig. 2.—*Hysterothylacium cayugensis; A,* Anterior extremity showing lateral alae, esophagus, cecum and intestine. *B,* Anterior extremity showing lip arrangement. *C,* Female, showing vulva, ovejector and divergent uteri.

of this early immature stage are: golden shiner, *Abramis chrysoleucus* (Mitchell); satin-fin shiner, *Notropis whipplei* (Girard); blunt-nosed minnow, *Pimephales notatus* (Rafinesque); barred killifish, *Fundulus heteroclitus* (Linn); Cayuga minnow, *Notropis cayuga* (Meek); common sun-fish, or pumpkin-seed, *Eupometis gibbosus* (L), and the common white sucker, *Catostomus commersoni* (Lacépède).

The size of the forms in the various hosts are as follows:

	Length mm.	Width mm.
Barred killifish	1.80 to 3.10	0.064 to 0.082
Blunt-nosed minnow	1.71 to 4.40	0.051 to 0.124
Cayuga minnow	1.65 to 3.10	0.048 to 0.082
Golden shiner	1.09 to 1.94	0.053 to 0.070
Satin-fin shiner	1.38 to 2.12	0.048 to 0.072
Sucker	1.16 to 2.09	0.048 to 0.072

The writer wishes to express his most grateful acknowledgment and appreciation to Dr. William A. Riley and to Dr. Maurice C. Hall for invaluable help in connection with the investigation and the preparation of the foregoing paper.

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THE DEVELOPMENT OF GREGARINES AND THEIR RELATION TO THE HOST TISSUES: (II) IN *CEPHALOIDOPHORA DELPHINIA* (WATSON)*

MINNIE WATSON KAMM

This paper is the second of a series in which the writer aims to depict the consecutive stages through which gregarines of various genera pass in becoming mature sporonts, and the relation, whether deleterious or not, which the parasite bears to the intestinal epithelium from which it receives its nourishment. The former paper (Kamm, 1917) contained a brief historical survey of previous investigations of a similar nature.

The parasite chosen in the present instance is *Cephaloidophora delphinia* (Watson), first described by the writer in 1916, the host being the large white beach flea, *Talorchestia longicornis* (Say), taken at Cold Spring Harbor, Long Island, in the summer of 1915. The alimentary tract was removed intact, fixed and preserved. Sections were cut at 4μ and stained with Delafield's hematoxylin. Parasitism was found to occur in more than 30 per cent. of the 260 intestines examined for live sporonts (Watson, 1916); even where gregarines are present, it is rare to find more than a dozen sporonts, and very few intracellular stages in a single host. It is almost by accident that a good infection is encountered.

The alimentary tract of the Gammaridea, a suborder of the Arthropoda, consists (Calman, 1909) of the stomodeum, a long mid-intestine, and a short proctodeum. In my preserved material, most of the stomodeum is missing, having been severed with the head of the flea. At the junction of stomadeum and mid-intestine in Talorchestia (Fig. 1) is found one pair of hepatic caeca longer than the rest of the alimentary tract and opening into the same by two ducts. At the union of mid-intestine and proctodeum occurs one pair of caeca opening into the alimentary tract by separate ducts. These caeca are about two-thirds the length of the mid-intestine, looped upon themselves, and finally extend down the proctodeum loosely attached at its side. How they open to the exterior is not determined, as the intestines were clipped off at the posterior end. The caeca are probably excretory in function; they are filled with calcareous concretions for hastening the hardening of the exoskeleton after moults. The proctodeum in Talorchestia is nearly as long as the mid-intestine. The former is much thinner-walled than the latter. From the intestinal content one

* Contributions from the Zoological Laboratory of the University of Illinois, No. 123.

sees that the flea feeds upon algae and decaying wood and insects, and it probably finds additional organic matter in dead crabs and fish.

The epithelial cells of the mid-intestine are thrown into fan-shaped lobes (Fig. 6); the individual cells are columnar and packed closely together, and are heavily ciliated on their free surfaces. They are rich in protoplasm, which is either fairly evenly distributed and lightly reticulate or abundant only in the coelomic portion, that part nearer the lumen often being vacuolated. In the proctodeum, where absorption is diminished, the cells are short and broad, more nearly cubical in shape, and the protoplasm is coarsely reticulate. A spiny chitinous lining is present here.

It is in the mid-intestine only that the young parasites find their temporary lodging place. Obviously, the mature free sporonts find conditions at an optimum in the same region where the absorption of chyle is at its maximum. Where sections reveal the presence of sporonts in the lower regions, it is probable that the parasites are being swept down on the periphery of compact food-masses, and are on their way to speedy destruction as the feces are formed and ejected. The mature sporonts, then, collect between the food-masses and the lumen of the mid-intestine for protection, and here also they are in the richest food belt (Fig. 9).

It is a noteworthy fact that no parasites have been found in the hepatic caeca, for in several species studied from insects parasites are found here almost as freely as in the intestine itself. No parasites were found outside the coelomic layer of the epithelium or boring their way through this layer, as was noted in *Stenophora lactaria* (Watson, 1916). Gametes taken from immature developing cysts do not differ in size, but there is a slight difference in staining reaction, indicating a possible sexual differentiation (Watson, 1916). Spores have not been seen to date, neither has the sporozoite been found, and therefore the first stage in intracellular development cannot be shown. Gregarines in all stages of development stain perfectly homogeneously, and for this reason are easily distinguished from surrounding tissue, even in very young stages.

The first stage seen in my sections (Fig. 2) indicates a tiny ovoidal unilocular intracellular parasite smaller than a normal cell-nucleus and situated near the base of the cell which has been penetrated. The trophozoite has begun to absorb nourishment from the cell, which is already vacuolated in the region of the parasite and the nucleus, being nearby, has already begun to shrivel from absorption and probably also from the effect of the parasite excretions. The cell shows no hypertrophy in this early stage.

In a slightly later but still septumless stage of development (Fig. 3) there is also no evidence of hypertrophy, but the originally parasitized cell and the two contiguous ones now show distinct signs of degeneration, the walls in the proximity of the parasite being less clearly defined and the protoplasm more vacuolate than in other parts of the cells. The nuclei have changed from ovoidal to irregularly dolioform in shape.

Figure 4 shows sections of somewhat later stages with more advanced changes in the destruction of the host cells. Where still remaining, nuclei of destroyed cells have shrivelled and stain very darkly, the chromatin granules only being left, and the outlines of the cells have become indistinct throughout.

The next stage (Fig. 5) is that of a small parasite in which a septum is formed dividing it into protomerite and deutomerite. These two parts already show slightly different staining reactions, the former, although containing fewer protoplasmic granules taking the color more readily, a feature characteristic of the parasite throughout the remainder of its life. A small papilla is now visible at the apex of the protomerite which is retained in the adult. Léger and Duboscq (1911) mention this as a "rudimentary structure" and Mercier (1912) calls it an epimerite. It is homologous with a similar structure in *Stenophora lactaria* (Kamm, 1917: 126), and both are obviously functionless. As stated for the one previously described, this structure is probably the vestige of an organ which was useful and functional in the past; and this theory would lead to the conclusion that gregarines without or with only vestigeal epimerites represent a higher stage of development than forms with a true functional epimerite in the cephalont stage.

Numerous instances have been found in which the parasite has located itself at the base of a lobular group of cells, and in growing is absorbing nourishment from the whole group at once—an arrangement highly advantageous to the parasite, but very destructive to the host tissues. In Figure 6 is shown (*a*) the cross-section of a small gregarine so located. The outline of that portion of the cells nearest the parasite is lost, but parts nearer the lumen still retain much of their individuality. The nuclei in the latter region are still but little affected, but if the nucleus happens to be situated near the parasite it is affected and soon becomes absorbed completely. This proves that nuclei in general are not more susceptible to the presence of the parasite than is the vegetative protoplasm of the cell. The cell-wall next the lumen and the ciliary boundary are the last to lose their identity and often when the entire cell-content has disappeared there is still considerable of the lobular contour left (Fig. 7). No hyper-

trophy is present, the apparent enlargement of the tissue in which the parasite is located being merely the normal contour of the lobules. Thus it is seen that the cells affected by the parasite do not become hypertrophied at any stage, but from the first are absorbed. Therefore, it is apparent that excretions of the gregarine do not seriously affect the cell protoplasm.

Léger and Duboscq (1911) speak of development at first as intracellular and later as intercellular; I should, however, scarcely call the position of parasites of this particular species, after many cells have been totally or partially destroyed, as intercellular.

That the gregarine may occupy any position within the epithelium is indicated in Figure 6, as at *a* it lies horizontal with the basal muscular layer and parallel with relation to the anterior-posterior direction of the intestine; in *b* it lies obliquely; in *c* it lies at right-angles to the long axis of both the intestine and the epithelial cells and in Figure 7 it is seen to lie perpendicular to the long axis of the intestine and parallel to the long axis of the cells. Mercier (1911) mentions that in *Cephaloidophora talitri* the position of the parasite within the cell is not constant. This diversity of position is quite in contrast to that in *Stenophora lactaria,* in which the parasite in almost every instance lay with the protomerite toward the muscular layer at all stages of its development (Kamm, 1917: 126). The explanation for this difference between the two species probably lies in the fact that in *S. lactaria* the parasite is crowded and has no room for movement, while in *C. delphinia* it has considerable freedom for rotation. In its growth *S. lactaria* rarely uses up more than a few cells, while *C. delphinia,* lying at the base of a whole group, uses protoplasm from all and thus gradually vacuolates a large space in which it is more and more free to move. Thus a moderate infection with *C. delphinia* is more destructive to its flea host than is a similar infection of *S. lactaria* to its milliped host.

After the whole parasitized space has been vacuolated and the nourishment has been exhausted, and when the walls next the lumen along with their ciliary boundary have disintegrated (Fig. 8), the parasite is free to give up its confinement and becomes free-living within the lumen of the canal. It is quite probable that the limiting wall is often violently ruptured by the increasingly active movements of the animal.

After the parasite has liberated itself and migrated into the lumen, it becomes a sporont. This departure is entirely due to accident, the parasite in its movements finding the opening which has been made into the lumen. The mode of assimilation of the sporont undergoes little change from that of the trophozoite; instead of receiving its

nourishment from the cell, food is absorbed before it is taken up by the cell. The animal leads a more or less sluggish life even when freed, for groups are found lying close to the cilia and embedded in mucous masses (Fig. 9; see also Watson, 1916, Fig. 3). Mature live sporonts measure approximately 110μ by 60μ.

After the cell-group is rid of its exhausting burden, it is practically destroyed; there is little protoplasm left and no nuclei to recover from the shock and with which to reconstruct the shattered group. Certain small barren areas are sometimes seen in cross-sections of the epithelium, and these structureless regions may be caused by destruction due to parasites. There are two other possibilities, however, concerning the vacated cells: The surrounding unaffected cells may gradually enlarge and close entirely over the space, or regeneration of the destroyed tissue may take place.

In instances of maximum infection noted, the effect of parasitism upon the host is undoubtedly deleterious. When twenty or more cells are completely destroyed by each parasite of a hundred or more developing at the same time, the absorptive capacity of the intestine is greatly diminished. I was, however, unable to prophesy from the action of live fleas which would be the more prolific in parasites, tho this had been done in the case of some hosts parasitized with enormous numbers of gregarines, or nematodes, or both (e. g., various grasshoppers and *Diabrotica vittata,* the cucumber beetle).

The parasite does not attain its maximum growth within the epithelium but grows considerably after becoming free (contrast Figs. 8 and 10). During its sporont life it becomes attached to another of its kind and ultimately the two conjoints form a cyst. This process has already been described for the species in question (Watson, 1916:131).

Three species were described by the writer in 1916 as *Frenzelina delphinia, F. olivia* and *F. nigrofusca* from beach fleas, fiddler crabs and littoral spider crabs. I find in a footnote in an article by Léger and Duboscq (1911) that the genus name *Frenzelina* Léger and Duboscq (1907) is preoccupied by a rhizopod, *Frenzelina* Penard 1902; and that the genus name for the gregarine becomes *Cephaloidophora,* given by Mawrodiadi in 1908. Therefore my three species become, respectively, *Cephaloidophora delphina, C. olivia* and *C. nigrofusca.*

SUMMARY

Consecutive stages in the growth of *Cephaloidophora delphinia* (Watson) are shown.

This species does not possess an epimerite.

Development is intracellular.

Many cells contribute to the nourishment of the parasite, all of which are ultimately destroyed.

No noticeable hypertrophy of either nucleus or vegetative protoplasm of the host cells is indicated.

Large infections are deleterious to the host.

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Explanation of Plate

The reference line is 0.03 mm. long.

Fig. 1.—Alimentary tract of *Talorchestia longicornis* (Say), from preserved material, *h c,* hepatic caeca; *m i,* mid-intestine; *e c,* excretory caeca; *p* proctodeum.

Fig. 2.—Early stage in growth of trophozoite, septumless, host cell-nucleus already affected.

Fig. 3.—Later stage, similar to last, contiguous cells being vacuolated.

Fig. 4.—Two cross-sections of young trophozoites, showing marked influence upon the epithelium.

Fig. 5.—Half-grown trophozoite with septum formed.

Fig. 6.—Parasites in three situations within host-tissue; (*a*) cross-section, position most favorable for absorbing nourishment from many cells; (*b*) oblique position, with marked destruction of tissue; (*c*) longitudinal section of nearly full-grown trophozoite.

Fig. 7.—Third position of parasite, parallel to long axis of the cells. Cell wall toward lumen weakened.

Fig. 8.—Cell wall broken preparatory to trophozoite migration.

Fig. 9.—Sporonts in lumen of upper proctodeum.

Fig. 10.—Mature associated sporonts, free in upper portion of proctodeum. Glycerine mount.

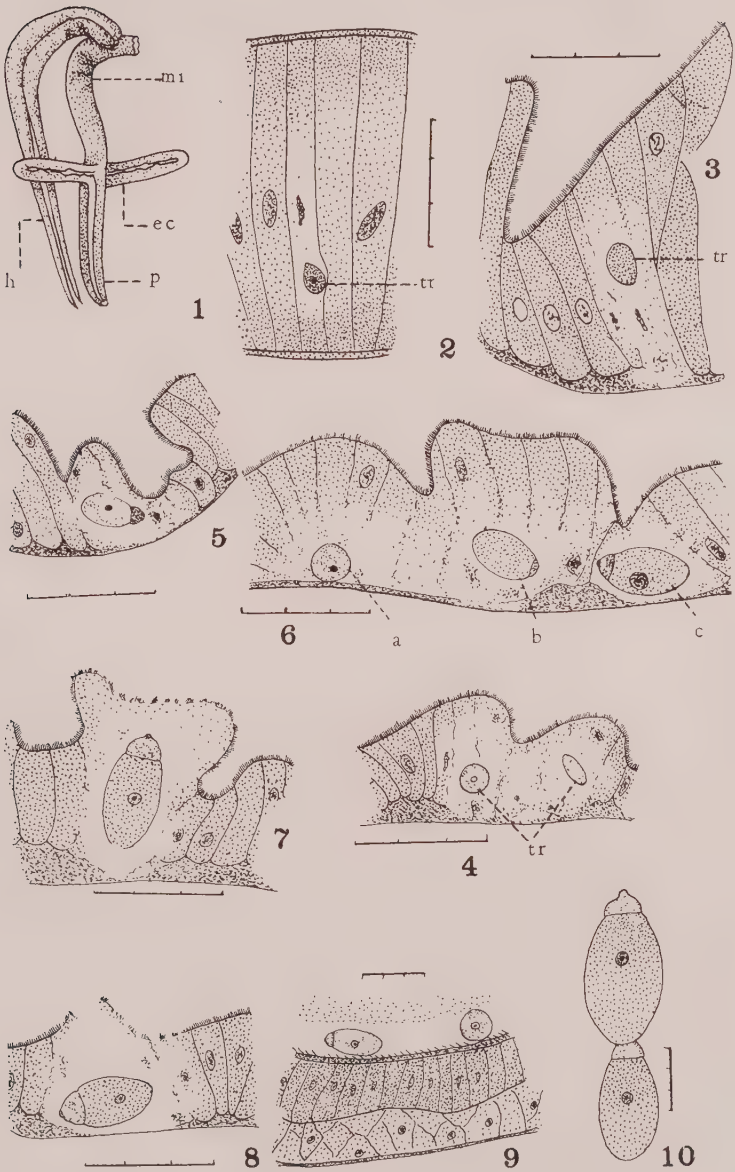

PLATE IV

ON THE LIFE CYCLE OF THE FOWL CESTODE, *DAVAINEA CESTICILLUS* (MOLIN)*

JAMES E. ACKERT

(Preliminary Communication)

Little is known of the means by which tapeworms are transmitted to fowls. Of the six species recorded from chickens in the United States, the life histories of but two have been demonstrated experimentally. *Davainea proglottina* (Davaine), rare in this country, may be transmitted by the slug, *Limax cinereus* Lister, according to Grassi and Rovelli (1889:372; 1892:86), and *Choanotaenia infundibuliformis* (Goeze) may have the house fly, *Musca domestica* Linn., (Gutberlet, 1916:235) as its intermediate host.

Recently, the writer has demonstrated experimentally that *Musca domestica* may transmit to chickens another tapeworm which appears to be *Davainea cesticillus* (Molin 1858) Blanchard 1891. The fowls used in the experiment were hatched in an incubator and placed at once in a fly-proof field cage which, with its floor and 18-inch walls of cement, is so constructed as to be worm-proof also. Examinations of control chickens every few weeks for four years have not yielded a single parasitic worm. In this field cage, the fowls were given food free from animal tissues, with the exception of some fresh beef and the experimental feedings.

House flies taken from nature were placed in small lantern globe cages and given living onchospheres from the fowl cestode, *D. cesticillus*. Onchospheres and portions of teased, gravid proglottids in a small drop of water were eagerly taken by the flies. The latter were then kept alive as long as possible to afford time for the development of larval tapeworms (cysticercoids) in the bodies of the flies. By giving to these caged flies small amounts of whole, sweet milk, fairly large numbers of them were kept alive for two or three weeks after feeding the onchospheres. As soon as the flies died, they were either preserved for sectioning or given to young chickens reared in the fly-proof field cage. In this way several hundred house flies were fed, a few at a time, to twelve chickens.

From these fowls, nine cestodes were taken, two from chick No. 165 being sexually mature. Control chickens from the same broods kept with the experimental ones in no case yielded a parasitic worm.

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* Contribution No. 24 from the Department of Zoology, Kansas State Agricultural College. Aid of Adams Fund.

Chick No. 165 was given a total of 245 house flies from August 25 to September 11, and on October 13 the examination revealed two cestodes in the small intestine both of which possessed gravid proglottids. They are described in the following.

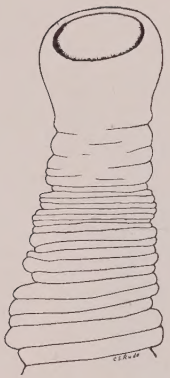
DIAGNOSIS

Length, 79 to 90 mm. Maximum width, 1.6 to 2.3 mm. Scolex (Fig. 1) cylindrical, 0.5 to 0.6 mm. wide and 0.3 to 0.4 mm. long. Suckers unarmed, about 0.1 mm. in diameter. Rostellum broad and hemispherical, 0.29 mm. wide, with approxixmately 200 very unstable hooks. Hooks (Fig. 2), 8 to 9μ long, with long ventral and short dorsal root. Neck very short, followed by proglottids equal to or greater in width than the scolex. Anterior proglottids, 3 to 6 times as broad as long; following ones increasing in size until length exceeds width; borders (Fig. 3) overlapping. Genital pores irregularly alternate, one in each proglottid somewhat in front of middle of lateral margin in young proglottids and nearer middle in older ones. Vagina and cirrus pouch (*c*) on dorsal side of two excretory canals and nerve.

Male reproductive organs: Testes (*t*), 20 in number in posterior portion of proglottid. Vas deferens (*v d*) coiled before entering base of cirrus pouch, also coiled within latter. Cirrus pouch ellipsoidal, 139 to 164μ long by 65 to 82μ wide. Cirrus when protracted, 131μ long and 13μ in diameter, armed with minute spines, and with bulbous enlargement 21μ in diameter at base becoming continuous with cirrus pouch.

Female reproductive organs: Vagina enlarged near median line into small seminal receptacle. Ovary (*o*) in middle field in front of testes. Yolk gland and shell gland posterior to ovary, ventral and dorsal, respectively. Uterus at first in front of ovary; gradually increasing in size, finally extending laterally to excretory canals and occupying most of proglottid; in oldest proglottids dividing into compartments or capsules each containing a single egg. Embryo (Fig. 4), 35 by 31μ in diameter, with very thin membrane closely adherent to its surface; embryo further enveloped by thicker, smooth membrane, oval in shape, 42 by 36μ in diameter; latter surrounded by thin, wrinkled membrane approximately 66 by 61μ in diameter; embryo and membranes finally enclosed in capsule of outer and inner layer.

The characteristic scolex with its broad, flat rostellum, the anterior proglottids as wide as the scolex, and the eggs in individual capsules in the posterior proglottids, together with the other diagnostic points



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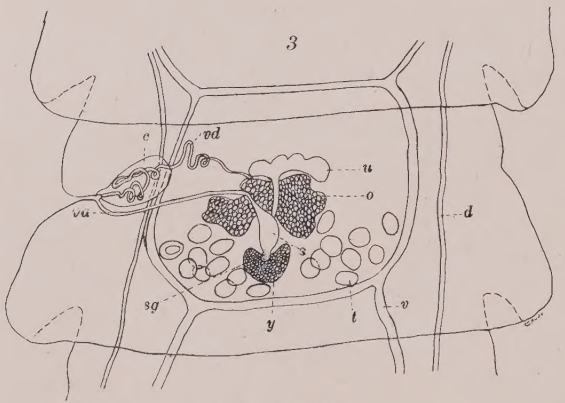

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PLATE V

appear to leave no doubt as to the identity of these worms. As the house flies constituted the only animal tissues (except fresh beef) given to the experimental chickens, the writer concludes that *Musca domestica* may transmit *Davainea cesticillus* to fowls.

Literature Cited

Grassi, B., and Rovelli, G. 1889. Embryologische Forschungen an Cestoden. Centralbl. f. Bakteriol., 1 Abt., 5: 370-377.

1892. Ricerche embriologiche sui Cestodi. Atti Accad. Gionia di Sci. Nat., Catania, (4) 4: 1-108.

Gutberlet, J. E. 1916. Studies on the Transmission and Prevention of Cestode Infection in Chickens. Jour. Am. Vet. Med. Assn., 2: 218-237.

Explanation of Plate

Fig. 1.—Scolex showing broad, flat rostellum and anterior proglottids. × 62.

Fig. 2.—Rostellar hooks. × 480.

Fig. 3.—Mature proglottid. Certain details were added from studies of transverse sections. × 103.

Fig. 4.—Embryo. × 668.

The drawings were made with the aid of a camera lucida.

Abbreviations

c, cirrus pouch
d, dorsal excretory canal
o, ovary
s g, shell gland
s, seminal receptacle
t, testes
u, uterus
va, vagina
v d, vas deferens
v, ventral excretory canal
y, yolk gland

REVIEWS AND NOTES

Under the title of "The Malaria Problem in Peace and War," Dr. Frederick L. Hoffman has published a valuable study of (1) modern methods for the eradication of malaria and their results, and (2) the relations of this disease to war. It is an exceedingly comprehensive presentation of materials from official sources, so condensed and well arranged as to be generally useful.

The 1917 annual report of the medical department in the United Fruit Company puts malaria as the most prevalent disease with one-third of all their cases; in 28,985 cases, however, they had only 54 deaths. Second in importance was hookworm; the records seem to show a distinct gradual decrease in the number of these cases in recent years. Amebic dysentery and a type of flagellate dysentery are also mentioned prominently in the report. *Clonorchis sinensis* was recorded from a Chinese laborer in Cuba, the first record for that region.

The Division of Biology of the California State Board of Health has been designated the Division of Parasitology. The program of this Division includes not only practical work on the hookworm in the mines of California, and on the parasites among the oriental and Mexican laborers of the state, but also a program of general research work in the field of parasitology. The division of parasitology is planning to build up a library and will be glad to receive publications along parasitological lines. The publication of special bulletins is provided for in the plan. Dr. C. A. Kofoid will be consulting parasitologist and Dr. W. W. Cort, consulting helminthologist.

It is with deep regret that the workers in parasitology have learned of the death, on February 16, at the age of 64, of Dr. F. M. Sandwith, C.M.G. Dr. Sandwith was well known for studies on tropical diseases, and was connected with the London School of Tropical Medicine.

Professor W. A. Riley, of the editorial board of THE JOURNAL, has been appointed professor of entomology and chief of the division of entomology and economic zoology at the University of Minnesota. He should be addressed at University Farm, St. Paul, Minnesota. By an error, Professor Riley's initials were misprinted in the March number of THE JOURNAL, on page 139.

In view of the evident need for army work of men, trained in the special field, a group in Washington, D. C., has been engaged in the study of disease-transmitting insects and methods for their control. Dr. W. Dwight Pierce has taken the leadership of the work which includes not only meetings for study and discussion, but correspondence with field men as well.

EDITOR'S NOTE

An unfortunate error, for which the author was not responsible, was made in the paper by M. W. Kamm in the last number of THE JOURNAL; the paragraph

GREGARINA DIABROTICA nov. spec. (Figs. 5 and 6)

Host: Diabrotica vittata Fabr. (Chrysomelidae).
Location: Urbana, Illinois, June, 1917.
Habitat: Intestine.

was printed at the bottom of page 162 instead of directly after the table at the bottom of 161, where it properly belongs.

The actual dates of issue of Volume IV of THE JOURNAL were as follows:

No. 1, October 16, 1917.
No. 2, January 19, 1918.
No. 3, April 8, 1918.
No. 4, September 14, 1918.